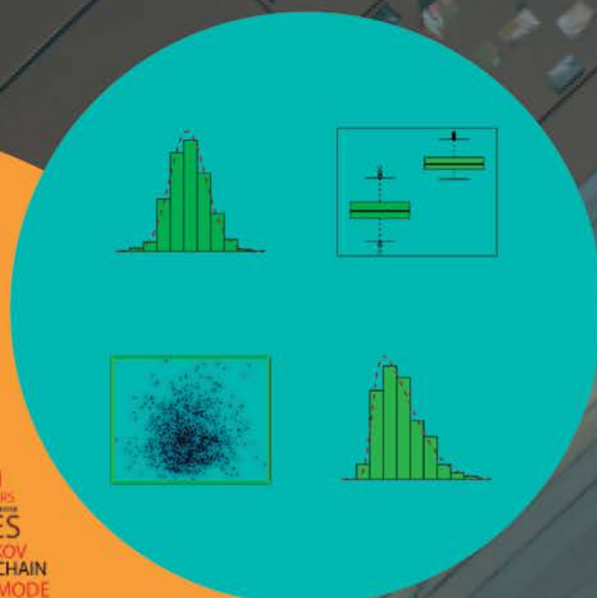
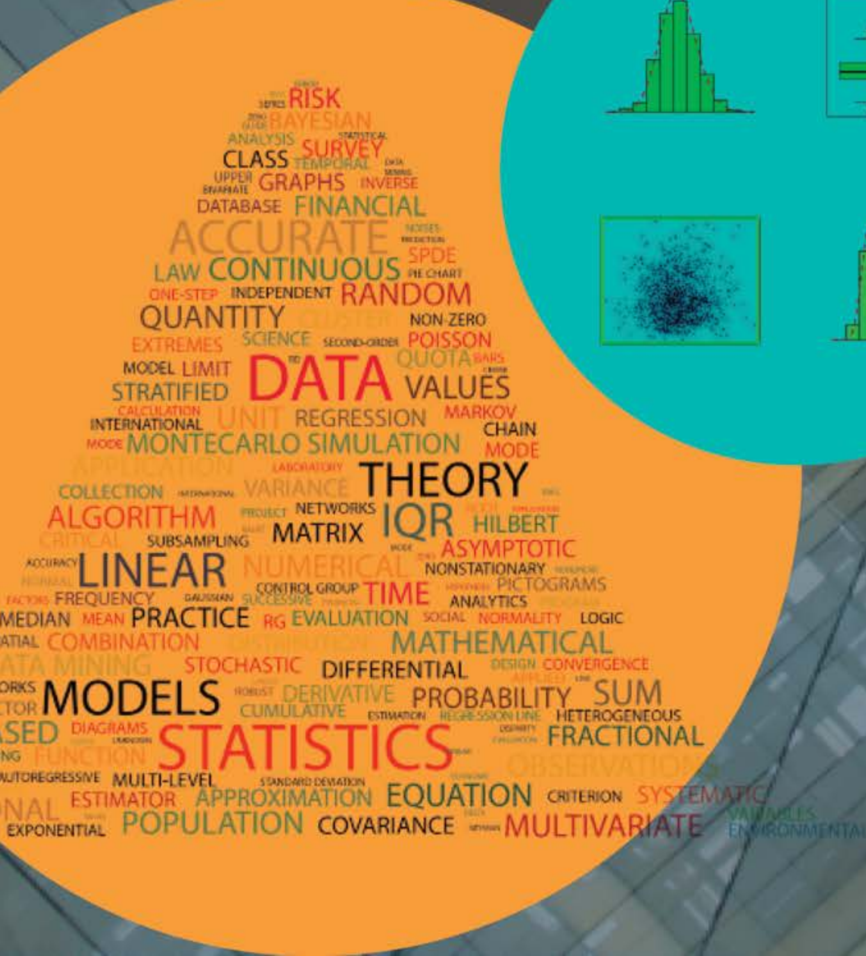
Statistics Program





Program Guide 2018-2019

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1. Aims and Scope

The Statistics (STAT) program educates students to analyze and model complex real-world problems arising in modern Statistical Data Science. Two degrees are offered: the M.S. degree (under either a Thesis or a Non-Thesis option) and the Ph.D. degree. Admission to one degree does not guarantee transfer to another. All students in the M.S. and Ph.D. programs are guided by a Faculty Advisor to develop their program of study.

2. Assessment Test (If applicable)

Students are admitted to KAUST from a wide variety of programs and backgrounds. In order to facilitate the design of an appropriate study plan for each individual student, all admitted students without an MS are required to take a written assessment exam when they arrive on Campus. The purpose of the assessment is to determine whether students have mastered the prerequisites for undertaking graduate-level courses taught in the program. The Academic Advisor works with admitted students to develop a study plan if needed. Students are encouraged to prepare for the assessment by refreshing the general knowledge gained from their undergraduate education before arriving at KAUST. The remedial study plan requirements must be satisfactorily completed, in addition to the University degree requirements.

3. Master's Degree Requirements

It is the sole responsibility of the student to plan her/his graduate program in consultation with her/his advisor. Students are required to meet all deadlines. Students should be aware that most core courses are offered only once per year.

The Master's Degree (M.S.) is awarded upon successful completion of a minimum of 36 credit hours. A minimum GPA of 3.0 must be achieved to graduate. Individual courses require a minimum of a 'B-' for course credit. Students are expected to complete the M.S. degree in three semesters and one Summer Session. Satisfactory participation in every KAUST's Summer Session is mandatory. Summer Session courses are credit bearing and apply towards the degree.

The M.S. degree has the following components:

- Core Courses
- Elective Courses
- Research/Capstone Experience
- Graduate Seminar 298 (non-credit). All students are required to register and receive a Satisfactory grade for the first two semesters.

3.1 M.S. Course Requirements

3.1.1 Core Courses (12 credits)

Students enrolled toward the M.S. degree are required to complete the following 12 credits of core courses:

STAT 220: Probability and Statistics
STAT 230: Linear Models
STAT 240: Bayesian Statistics
STAT 250: Stochastic Processes

The core courses are designed to cover the basic skills and competencies that are expected of any student holding an advanced degree. STAT 220, 230, 250 are part of the Ph.D. Qualifying Examination.

3.1.2 Elective Courses (12 credits)

The elective courses (which exclude research, internship credits, and IED courses) are designed to allow each student to tailor his/her educational experience to meet individual research and educational objectives, with the permission of the student's academic advisor.

Students enrolled toward the M.S. degree are required to complete 12 credits of elective courses (some of these possible elective courses from the STAT, AMCS, CS, EE, ErSE programs are listed in Section 5).

3.1.3 Research/Capstone Experience

See sections for thesis and non-thesis options below.

3.1.4 Winter Enrichment Program

Students are required to satisfactorily complete at least one full Winter Enrichment Program (WEP).

3.2 M.S. Thesis Option

Students wishing to pursue the thesis option must apply by the ninth week of their second semester for a thesis and must have at least a 3.2 cumulative GPA.

The selected thesis advisor must be a fulltime program-affiliated Assistant, Associate or Full Professor at KAUST. This advisor can only become project affiliated for the specific thesis project upon program level approval. Project affiliation approval must be completed prior to commencing research.

3.2.1 M.S. Thesis Defense Requirements

An oral defense of the M.S. Thesis is required, although it may be waived by the Dean's Office under exceptional circumstances. A requirement of a public presentation and all other details are left to the discretion of the thesis committee.

A written thesis is required. It is advisable that the student submits a final copy of the thesis to the Thesis Committee Members at least two weeks prior to the defense date.

- Students are required to comply with the university formatting guidelines provided by the library **CLICK HERE**
- Students are responsible for scheduling the thesis defense date with his/her thesis committee.
- A pass is achieved when the committee agrees with no more than one dissenting vote, otherwise the student fails. The final approval must be submitted at the latest two weeks before the end of the semester.

3.2.2 M.S. Thesis Defense Committee

The M.S. Thesis Defense Committee, which must be approved by the student's Dean, must consist of at least three members and typically includes no more than four members. At least two of the required members must be KAUST Faculty. The Chair, plus one additional Faculty Member must be affiliated with the student's program. This membership can be summarized as:

Member Role Program Status

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty or Approved Research Scientist	Outside Program

4	Additional Faculty	Inside or Outside KAUST

Notes:

- Members 1-3 are required. Member 4 is optional.
- Co-Chairs may serve as Members 2, 3, or 4, but may not be a Research Scientist.
- Adjunct Professors and Professors Emeriti may retain their roles on current Committees, but may not serve as Chair on any new Committees.
- Professors of Practice and Research Professors may serve as Members 2, 3 or 4 depending upon their affiliation with the student's program. They may also serve as Co-Chairs.
  - Visiting Professors may serve as Member 4.

View a list of faculty and their affiliations: **CLICK HERE**

3.3 M.S. Non-Thesis Option

Students wishing to pursue the non-thesis option must complete a minimum of six credits of Directed Research (299). Summer internship credits may be used to fulfill the research requirements provided that the Summer internship is research-based. Summer internships are subject to approval by the student's academic advisor.

Students must complete the remaining credits through one or a combination of the options listed below:

- Broadening Experience Courses: Courses that broaden a student's M.S. experience.
- Internship: Research-based Summer Internship (295). Students are only allowed to take one internship.
- PhD Courses: Courses numbered at the 300 level.

4. Doctor of Philosophy

The Doctor of Philosophy (Ph.D.) Degree is designed to prepare students for research careers in academia and industry. It is offered exclusively as a fulltime program.

There is a minimum residency requirement at KAUST of three and a half years for students entering with a B.S. Degree and two and a half years for students entering with a M.S. Degree. A minimum GPA of 3.0 must be achieved on all doctoral coursework. Individual courses require a minimum of a 'B-' to earn course credit.

The Ph.D. Degree includes the following steps:

- Securing a Dissertation Advisor.
- Successful completion of Program Coursework.
- Passing the Qualifying Examination.
- Passing the Dissertation Proposal Defense to obtain candidacy status.
- Preparing, submitting and successfully defending a Doctoral Dissertation.

4.1 Ph.D. Course Requirements

The required coursework varies for students entering the Ph.D. Degree with a B.S. Degree or a relevant M.S. Degree. Students holding a B.S. Degree must complete all Program Core/Mandatory Courses and Elective Courses outlined in the M.S. Degree section and are also required to complete the Ph.D. courses below. Students entering with a B.S. Degree may also qualify to earn the M.S. Degree by satisfying the M.S. Degree requirements; however, it is the student's responsibility to declare their intentions to graduate with an M.S.

Students entering the Ph.D. Degree with a relevant M.S. Degree must complete the requirements below, though additional courses may be required by the Dissertation Advisor.

Ph.D. Courses

- At least four courses of which at least two must be from the STAT 300 level course list.
- Graduate Seminar 398 (non-credit): All students are required to register and receive a Satisfactory grade for the first two semesters.
- Winter Enrichment Program: Students are required to satisfactorily complete at least one full Winter Enrichment Program (WEP) as part of the degree requirements. Students who completed WEP requirements while earning the M.S. Degree are not required to enroll in a full WEP for a second time in the Ph.D. Degree.
- Satisfactory participation in every KAUST's Summer Session is mandatory. Summer Session courses are credit bearing and apply towards the degree.

4.2 Ph.D. Designation of Dissertation Advisor

The selected Dissertation Advisor must be a full time program-affiliated Professor at KAUST. The student may also select an advisor from another program at KAUST. This advisor can only become project affiliated for the specific thesis project with program level approval. Project affiliation approval must be completed prior to commencing research.

View a list of faculty and their affiliations: **CLICK HERE**

4.3 Ph.D. Candidacy

In addition to the coursework requirements, the student must successfully complete the required Ph.D. qualification milestones to progress towards Ph.D. candidacy status. These milestones consist of the subject-based qualifying examination and Ph.D. Proposal Defense.

4.3.1 Ph.D. Dissertation Proposal Defense Committee

The Ph.D. Dissertation Proposal Defense Committee, which must be approved by the student's Dean, must consist of at least three members and typically includes no more than six members. The Chair, plus one additional Faculty Member must be affiliated with the student's Program.

Member Role Program Status

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty	Outside Program
4	Approved Research Scientist	Inside KAUST

Notes:

- Members 1-3 are required. Member 4 is optional.
- Co-Chairs may serve as Members 2 or 3.
- Adjunct Professors and Professors Emeriti may retain their roles on current Committees, but may not serve as Chair on any new Committees.
- Professors of Practice and Research Professors may serve as Members 2 or 3 depending upon their affiliation with the student's program. They may also serve as Co-Chairs.

Once constituted, the composition of the Proposal Committee can only be changed with the approval of both the Dissertation Advisor and the Dean.

View a list of faculty and their affiliations: **CLICK HERE**

4.3.2 Ph.D. Dissertation Proposal Defense

The purpose of the Dissertation Proposal Defense is to demonstrate that the student has the ability and is adequately prepared to undertake Ph.D.-level research in the proposed area. This preparation includes necessary knowledge of the chosen subject, a review of the literature and preparatory theory or experiment as applicable.

The Dissertation Proposal Defense is the second part of the qualification milestones that must be completed to become a Ph.D. Candidate. Ph.D. students are required to complete the Dissertation Proposal Defense within the second year of doctoral studies. The Dissertation Proposal Defense includes two aspects: a written Research Proposal and an oral Research Proposal Defense. Ph.D. students must request to present the Dissertation Proposal Defense to the Proposal Dissertation Committee at the beginning of the Semester they will defend their proposal.

There are four possible outcomes from this Dissertation Proposal Defense:

- Pass
- Pass with conditions
- Fail with retake
- Fail without retake

A pass is achieved when the committee agrees with no more than one dissenting vote, otherwise the students fails.

In the instance of a Pass with Conditions, the entire committee must agree on the required conditions and if they cannot, the Dean decides. The deadline to complete the conditions is one month after the defense date, unless the committee unanimously agrees to change it.

In the instance of a Fail without Retake, the decision of the committee must be unanimous. The deadline to complete the retake is six months after the defense date, unless the committee unanimously agrees to reduce it. Students who fail the Dissertation Proposal Defense, or who fail the Retake will be dismissed from the University.

A student who successfully passes the Dissertation Proposal Defense is deemed a Ph.D. Candidate.

4.4 Ph.D. Defense

To graduate, a Ph.D. candidate has to form a Ph.D. Dissertation Defense Committee, finalize the Ph.D. dissertation and successfully defend his/her Ph.D. dissertation.

4.4.1 Ph.D. Dissertation Defense Committee

The Ph.D. Dissertation Defense Committee, which must be approved by the student's Dean, must consist of at least four members and typically includes no more than six members. At least three of the required members must be KAUST Faculty and one must be an Examiner who is external to KAUST. The Chair, plus one additional Faculty Member must be affiliated with the student's Program. The External Examiner is not required to attend the Defense, but must write a report on the dissertation and may attend the Dissertation Defense at the discretion of the Program.

Member Role Program Status

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty	Outside Program

4	External Examiner	Outside KAUST
5	Approved Research Scientist	Inside KAUST
6	Additional Faculty	Inside or outside KAUST

Notes:

- Members 1-4 are required. Members 5 and 6 are optional.
- Co-Chairs may serve as either members 2, 3 or 6.
- Adjunct Professors and Professors Emeriti may retain their roles on current Committees, but may not serve as Chair on any new Committees.
- Professors of Practice and Research Professors may serve as members 2, 3 or 6 depending upon their affiliation with the student's Program. They may also serve as Co-Chairs.
- Visiting Professors may serve as member 6, but not as the External Examiner.

The only requirement with commonality with the Proposal Committee is the Supervisor, although it is expected that other members will carry forward to this committee.

If the student has a co-supervisor, this person can be considered one of the above four members required, provided they come under the categories listed (i.e. meets the requirements of the position).

4.4.2 Ph.D. Dissertation Defense

The Ph.D. Degree requires the passing of the defense and acceptance of the dissertation. The final defense is a public presentation that consists of an oral defense followed by questions and may last a maximum of three hours.

The student must determine the defense date with agreement of all the members of the Dissertation Committee, meet deadlines for submitting graduation forms and inform the committee of his/her progress. It is the responsibility of the student to submit the required documents to the Graduate Program Coordinator at the beginning of the semester they intend to defend. It is also expected that the student submits their written dissertation to the committee at least two months prior to the defense date in order to receive feedback.

The written dissertation is required to comply with the University Formatting Guidelines which are on the library website: **CLICK HERE**

There are four possible outcomes from this Dissertation Final Defense:

- Pass
- Pass with conditions
- Fail with retake
- Fail without retake

A pass is achieved when the committee agrees with no more than one dissenting vote, otherwise the student fails. If more than one member casts a negative vote, one retake of the oral defense is permitted if the entire committee agrees. In the instance of a 'Pass with Conditions', the entire committee must agree on the required conditions and if they cannot, the Dean decides. The deadline to complete the revisions is up to one month after the defense date, unless the committee unanimously agrees to reduce it. The deadline to complete the retake is as decided by the defense committee with a maximum of six months after the defense date, unless the committee unanimously agrees to reduce it. Students who fail without retake the Dissertation Defense or who fail the retake will be dismissed from the University.

Evaluation of the Ph.D. Dissertation Defense is recorded by submitting the Result of Ph.D. Dissertation Defense Examination form within three days after the Defense to the Registrar's Office.

5. Program Courses and Descriptions

Course Notation:

Each course is listed prefaced with its unique number and post fixed with (L-C-R) where:

L = the lecture hours to count towards fulfilling the studentworkload during the semester.
C = the recitation or laboratory hours
R = the credit hours towards fulfilling a degree course requirement.

E.g. CS 220 Data Analytics (3-0-3) has a total of three hours of lectures per week, has no labs and earns three credits for the semester.
100-level courses are preparatory in nature and do not count towards the MS or PhD degrees.

5.1 STAT Program

STAT 199 – Directed Study in Statistics (3-0-0) (variable credit up to a maximum of 12 credits)
A course of self-study in a particular topic as directed by faculty and approved by the division.

STAT 210 – Applied Statistics and Data Analysis (3-0-3) (Equivalent to AMCS 110)
Prerequisites: Advanced and multivariate calculus. For students outside STAT wishing to obtain an introduction to statistical method. No degree credits for STAT or AMCS majors.
Provides fundamentals of probability and statistics for data analysis in research. Topics include data collection, exploratory data analysis, random variables, common discrete and continuous distributions, sampling distributions, estimation, confidence intervals, hypothesis tests, linear regression, analysis of variance, two-way tables and data analysis using statistical software.

STAT 220 – Probability and Statistics (3-0-3)
Prerequisites: Advanced and multivariable calculus, linear algebra.
This course is an introduction to probability and statistic for students in statistics, applied mathematics, electrical engineering and computer science. This core course is intended to provide a solid general background in probability and statistics that will form the basis of more advanced courses in statistics. Content: Probability; Random variables; Expectation; Inequalities; Convergence of random variables. Statistical inference: Models, statistical inference and learning; Estimating the CDF and statistical functionals; The bootstrap; Parametric inference; Hypothesis testing and p-values; Bayesian inference; Statistical decision theory. Statistical models and methods: Multivariate models; Inference about independence.

STAT 230 – Linear Models (3-0-3)
Prerequisites: Advanced and multivariable calculus, linear algebra.
This course is an introduction to the formulation and use of the general linear model, including parameter estimation, inference and the use of such models in a variety of settings. Emphasis will be split between understanding the theoretical formulation of the models and the ability to apply the models to answer scientific questions.

STAT 240 – Bayesian Statistics (3-0-3)
Prerequisites: Advanced and multivariable calculus, linear algebra.
This course will provide an introduction to the theory and methods of Bayesian statistics. In Bayesian statistics, one's inference about parameters and hypotheses are updated, using Bayes rule, as evidence/data accumulates. We will discuss the theory and how to do Bayesian data analysis. Computational aspects will also be discussed, and we will make use of R, JAGS/Stan, to do the inference.

STAT 250 – Stochastic Processes (3-0-3)

Prerequisites: Advanced and multivariate calculus, linear algebra.
Introduction to probability and random processes. Topics include probability axioms, sigma algebras, random vectors, expectation, probability distributions and densities, Poisson and Wiener processes, stationary processes, autocorrelation, spectral density, effects of filtering, linear least-squares estimation and convergence of random sequences.

STAT 260 – Nonparametric Statistics (3-0-3)

Prerequisites: STAT 220, 230, 240 and 250 or permission of instructor.
This course is an introduction to nonparametric function estimation. Topics include kernels, local polynomials, Fourier series, spline methods, wavelets, automated smoothing methods, cross-validation, large sample distributional properties of estimators, lack-of-fit tests, semiparametric models, recent advances in function estimation.

STAT 290A – Special Topic in Statistical Data Science in R (3-0-3)

Corequisites: STAT 220, 230, 250, or permission of instructor
Statistical Data Science in R teaches the details involved in solving real computational problems encountered in data analysis through a collection of case studies. It reveals the dynamic and iterative process by which data analysts approach a problem and reason about different ways of implementing solutions.

STAT 294 – Contemporary Topics in Statistics (3-0-0)

A course of current interest. Topics are not permanent and the content of the course will change to reflect recurring themes and topical interest. The content will be approved by the division.

STAT 295 – Internship

Master-level supervised research.

STAT 297 – Thesis Research (variable credit)

Master-level supervised thesis research.

STAT 298 – Graduate Seminar (non-credit)

Master-level seminar focusing on special topics within the field.

STAT 299 – Directed Research (variable credit)

Prerequisite: Sponsorship of advisor and approved prospectus. Master-level supervised research.

STAT 310 – Environmental Statistics (3-0-3)

Prerequisites: STAT 220, 230, 240, 250.
This course is an introduction to statistical methods for environmental data, with a focus on applications. Learn, discuss and apply statistical methods to important problems in environmental sciences. Topics include sampling, capture-recapture methods, regression, toxicology, risk analysis, time series, spatial statistics and environmental extremes.

STAT 320 – Advanced Statistical Inference (3-0-3)

Prerequisite: STAT 220, 230, 240, 250.
The course aims to provide a solid presentation of the main approaches to statistical inference, in particular of those formulations based on the so-called likelihood function, and of the most important statistical methods in current use for data modeling and for the interpretation of the uncertainty inherent in the conclusions from statistical analyses. The course is intended for students in science, engineering and statistics. At the end of the course, the student should be able to select and apply the main statistical procedures to a wide range of practical problems.

STAT 330 – Multivariate Statistics (3-0-3)

Prerequisite: STAT 220, 230, 240, 250.

An introduction to multivariate statistical models, well balancing three equally important elements: the mathematical theory, applications to real data, and computational techniques. Traditional multivariate models and their recent generalizations to tackle regression, data reduction and dimensionality reduction, classification, predictor and classifier instability problems. Tools for analyzing unstructured multivariate data.

STAT 340 – Computational Statistics (3-0-3)

Prerequisites: STAT 220, 230, 240, 250.

This course discusses computational techniques for statistical inference, including exact recursions for hidden Markov chains, Gaussian Markov random fields and their applications in latent Gaussian models, inference for latent Gaussian models using Markov chain Monte Carlo with block-sampling and auxiliary variables, deterministic approximations using integrated nested Laplace approximations (INLA), and the EM algorithm.

STAT 350 – Time Series Analysis (3-0-3)

Prerequisites: STAT 220, 230, 240, 250.

This course will cover models for analyzing time series data from both time and frequency domain perspectives. The emphases will be a balance of theory and applications. The course is intended to prepare the student for methodological research in this area and to train the students on cutting-edge data analytic methods for time series. The primary topics include ARMA/ARIMA models; spectral and coherence estimation; transfer function modeling; and classification and discrimination of time series. The course will conclude with advanced topics on non-stationary time series, time-frequency analysis and state-space models.

STAT 360 – Functional Data Analysis (3-0-3)

Prerequisites: STAT 220, 230, 240, 250, 260.

This course will be a broad overview of the analysis of data of multiple curves that may be considered to arise from smooth functions. The course is intended to prepare the students for methodological research in this area and to train them on cutting-edge methods for analyzing functional data. The primary topics covered include visualization of curves and data exploration, nonparametric smoothing (including splines and wavelets), functional principal components analysis, mixed effects models and functional mixed effects models.

STAT 370 – Spatial Statistics (3-0-3)

Prerequisite: STAT 220, 230, 240, 250. Recommended: STAT 320.

This course is an introduction to the concepts and applications of spatial statistics. It covers the following topics. Geostatistical data: Random Fields; Variograms; Covariances; Stationarity; Non-stationarity; Kriging; Simulations. Lattice data: Spatial regression; SAR, CAR, QAR, MA models; Geary/Moran indices. Point patterns: Point processes; K-function; Complete spatial randomness; Homogeneous/ inhomogeneous processes and Marked point processes.

STAT 380 – Statistics of Extremes (3-0-3)

Prerequisites: STAT 220, 230, 240, 250. Recommended: STAT 320, 370.

This advanced statistics course aims at providing a rather deep understanding of Extreme-Value Theory results, models, and methods, as well as some experience in the practical application of these tools to real data using the statistical software R. Theoretical and practical aspects will be covered. Topics covered include (a) Univariate Extreme-Value Theory: Extremal-Types Theorem; GEV distribution; return levels; Domains of attraction; Threshold-based methods; GPD distribution; Point process representation; r-largest order statistics approach; Likelihood inference; Modelling of non-stationarity; Dependent time series; Clustering and declustering approaches. (b) Multivariate Extreme-Value Theory: Modelling of componentwise maxima; Spectral representation; Parametric models; Dependence measures;

Asymptotic dependence/independence; Threshold methods; Likelihood-based inference. (c) Spatial Extremes: Gaussian processes; correlation functions; Max-stable processes and models.

STAT 394 – Contemporary Topics in Statistics (3-0-0)
A course of current interest. Topics are not permanent and the content of the course will change to reflect recurring themes and topical interest. The content will be approved by the division.

STAT 395 – Internship (variable credit)
Doctoral-level supervised research.

STAT 397 – Dissertation Research (variable credit)
Doctoral-level supervised dissertation research.

STAT 398 – Graduate Seminar (non-credit)
Doctoral-level seminar focusing on special topics within the field.

STAT 399 – Directed Research (variable credit)
Prerequisite: Sponsorship of advisor. Supervised research.

5.2 AMCS Program
Courses from the AMCS program can be taken as elective courses as agreed with the academic advisor. Relevant AMCS courses from faculty affiliated to the STAT program are listed below (but not limited to).

AMCS 206 – Applied Numerical Methods (3-0-3)
Prerequisites: Advanced and multivariate calculus.
A fast-paced one-semester survey of numerical methods for engineers and scientists, with an emphasis on technique and software. Computer representation of numbers and floating point errors. Numerical solution of systems of linear and nonlinear algebraic equations, interpolation, least squares, quadrature, optimization, nonlinear equations, approximation of solutions of ordinary and partial differential equations. Truncation error, numerical stability, stiffness, and operation and storage complexity of numerical algorithms.

AMCS 211 – Numerical Optimization (3-0-3)
Prerequisites: Advanced and multivariate calculus and elementary real analysis.
Solution of nonlinear equations. Optimality conditions for smooth optimization problems. Theory and algorithms to solve unconstrained optimization; linear programming; quadratic programming; global optimization; general linearly and non-linearly constrained optimization problems.

AMCS 308 – Stochastic Methods in Engineering (3-0-3)
Prerequisites: Basic probability, numerical analysis, and programming.
Review of basic probability; Monte Carlo simulation; state space models and time series; parameter estimation, prediction and filtering; Markov chains and processes; stochastic control; Markov chain Monte Carlo. Examples from various engineering disciplines.

AMCS 336 – Numerical Methods for Stochastic Differential Equations (3-0-3)
Prerequisites: knowledge of basic probability, numerical analysis, and programming.
Brownian motion, stochastic integrals and diffusions as solutions of stochastic differential equations. Functionals of diffusions and their connection with partial differential equations. Weak and strong approximation, efficient numerical methods and error estimates. Jump diffusions.

AMCS 350 – Spectral Methods for Uncertainty Quantification (3-0-3)
Prerequisites: Consent of instructor.
This course is an advanced introduction to uncertainty propagation and quantification in model-based simulations. Examples are drawn from a variety of engineering and science applications, emphasizing

systems governed by ordinary or partial differential equations. The course will emphasize a probabilistic framework and will survey classical and modern approaches, including sampling methods and techniques based on functional approximations.

5.3 CS Program

Courses from the CS program can be taken as elective courses as agreed with the academic advisor. Relevant CS courses from faculty affiliated to the STAT program are listed below (but not limited to).

CS 220 – Data Analytics (3-0-3)

Prerequisites: Students who take this course are assumed to be familiar with algorithm runtime analysis (e.g., big O notations), probability theory (e.g., Gaussian distribution and conditional probability), and programming language (e.g., MATLAB or C++).
The course covers basic concepts and algorithms for artificial intelligence, data mining and machine learning. The main contents are: artificial intelligence (task environment, performance measure, and problem solving by searching), data mining (data and patterns, summary statistics and visualization, unsupervised feature selection, and supervised feature selection), and machine learning (cross validation and supervised learning).

CS 229 – Machine Learning (3-0-3)

Prerequisites: linear algebra and basic probability and statistics. Familiarity with artificial intelligence recommended.
Topics: linear and non-linear regression, nonparametric methods, Bayesian methods, support vector machines, kernel methods, Artificial Neural Networks, model selection, learning theory, VC dimension, clustering, EM, dimensionality reduction, PCA, SVD and reinforcement learning.

CS 320 – Probabilistic Graphical Models (3-0-3)

Prerequisites: Students are expected to be familiar with probability theory, algorithms, machine learning and programming language.
This is a research-oriented graduate-level course on PGMs. The course will cover two main types of PGMs, i.e., directed PGMs and undirected PGMs. For directed PGMs we will cover Bayesian networks with one of its most important variants, hidden Markov models. For undirected PGMs, we will cover Markov networks (or Markov random fields) with one of its most important variants, conditional random fields. Therefore, the course contains four (4) parts: Bayesian networks, hidden Markov models, Markov networks and conditional random fields. In each part, motivations, ideas, definitions, examples, properties, representations, inference algorithms, and applications for the corresponding PGM will be introduced. This is done through lectures by the instructor. In the next two lectures, the students will present recommended research papers and lead in-class discussions. The last lecture of each part will be an in-class quiz, the purpose of which is not to judge their ability of calculation or memorization, but to push them to think more and deeper about the contents introduced in lectures. The course will finish by a final exam lecture and two project presentation lectures. The projects are expected to be a real application or a serious theoretical work of PGMs on real research problems.

CS 340 – Computational Methods in Data Mining (3-0-3)

Prerequisites: Probability and scientific computing.
Focus is on very-large-scale data mining. Topics include computational methods in supervised and unsupervised learning, association mining and collaborative filtering. Individual or group applications-oriented programming project. 1 credit without project; 3 credits requires final project.

5.4 EE Program

Courses from the EE program can be taken as elective courses as agreed with the academic advisor. Relevant EE courses from faculty affiliated to the STAT program are listed below (but not limited to).

EE 242 – Digital Communications and Coding (3-0-3)

Prerequisite: Probability and Random variables/Basic knowledge of linear Algebra.

Digital transmission of information across discrete and analog channels. Sampling; quantization; noiseless source codes for data compression: Huffman's algorithm and entropy; block and convolutional channel codes for error correction; channel capacity; digital modulation methods: PSK, MSK, FSK, QAM; matched filter receivers. Performance analysis: power, bandwidth, data rate and error probability.

EE 251 – Digital Signal Processing and Analysis (3-0-3)

Prerequisite: adequate background in linear algebra, multivariate optimization, signals and systems, Fourier series and Fourier transform.

It addresses the following topics: sampling and quantization, multirate digital systems, discrete Fourier transform (DFT), windowed DFT, fast Fourier transform (FFT), digital filter design, decimation and interpolation filters, linear predictive coding, and an introduction to adaptive filtering.

EE 341 – Information Theory (3-0-3)

Prerequisite: AMCS 241 or consent of instructor.

The concepts of source, channel, rate of transmission of information. Entropy and mutual information. The noiseless coding theorem. Noisy channels, the coding theorem for finite state zero memory channels. Channel capacity. Error bounds. Parity check codes. Source encoding.

EE 353 – Adaptive Signal Processing (3-0-3)

Prerequisite: AMCS 241, EE 251.

The Theory and applications of adaptive filtering in systems and signal processing. Iterative methods of optimization and their convergence properties: transversal filters; LMS (gradient) algorithms. Adaptive Kalman filtering and least-squares algorithms. Specialized structures for implementation (e.g., least-squares lattice filters, systolic arrays). Applications to detection, noise canceling, speech processing and beam forming.

EE 354 – Introduction to Computer Vision (3-0-3)

Prerequisite: Multivariable calculus and linear algebra.

The course gives an introductory overview of concepts (e.g. photometric and multi-view stereoscopy, epipolar geometry, interest point detection and description), problems (e.g. image-to-image matching and alignment, image classification, clustering/ segmentation, face recognition) and methodology (e.g. linear/nonlinear image filtering, RANSAC for robust fitting, discriminative and generative models) in the field of computer vision. It is intended to provide a solid background for students, who are planning to do research in visual computing.

EE 355 – Estimation, Filtering and Detection (3-0-3)

Prerequisite: AMCS 241.

Principles of estimation, linear filtering and detection. Estimation: linear and nonlinear minimum mean squared error estimation and other strategies. Linear filtering: Wiener and Kalman filtering. Detection: simple, composite, binary and multiple hypotheses. Neyman-Pearson and Bayesian approaches.

5.5 ErSE Program

Courses from the ErSE program can be taken as elective courses as agreed with the academic advisor. Relevant ErSE courses from faculty affiliated to the STAT program are listed below (but not limited to).

ErSE 213 – Inverse Problems (3-0-3)

Prerequisite: Linear algebra, probability theory, multivariate calculus, strong programming skills in Matlab. This course will introduce the principles of Inverse theory and data assimilation with applications to geophysics and other sciences. Both deterministic and stochastic viewpoints will be covered. Subjects studied will include topics such as least squares, generalized inverses, regularization, Kalman filter, adjoint method, etc. Techniques for solving nonlinear inverse and data assimilation problems will be also covered.

ErSE 253 – Data Analysis in Geosciences (3-0-3)

Prerequisite: Undergraduate statistics and some Matlab programming experience.
Processing of multidimensional data, spatial statistics including variogram, covariance analysis and modeling, multipoint estimation, spatial interpolation including statistical methods (kriging) and dynamical methods (Kalman filter), uncertainty assessment, cross validation, multivariate analysis including principal component analysis and canonical analysis.

ErSE 353 – Data Assimilation (3-0-3)

Prerequisite: ErSE 253
Data assimilation (DA) is the process of optimally combining observations with the predictions of numerical models to make the best possible estimate of the time-varying state of the phenomenon under study. In particular, DA forms a basis for the forecast of the future and re-analysis of the past. In the last 20 years, DA has gained center stage in many computational disciplines at both universities and research centers starting with geoscience applications. DA is a subject that requires a balanced understanding of statistics and applied mathematics as well as the relevant geophysical systems. This course introduces the concepts of data assimilation derived in the context of the statistical estimation theory and the deterministic inverse theory. The course covers a variety of assimilation methods for numerical weather prediction, ocean forecasting, reservoir history matching, 4D seismic inversion, and hydrology assimilation. These include, but not limited to, optimal interpolation and three-dimensional variational (3D-VAR) methods, Kalman-filtering, smoothing and four-dimensional variational (4D-VAR) methods, low-rank Kalman filtering, ensemble Kalman filtering and ensemble square-root filters. Advanced topics based on the fully nonlinear Bayesian estimation theory, such as the particle filter and the Gaussian-Mixture filters, and the state-of-art data assimilation systems will also be discussed.

6. University Wide Courses

University wide courses are courses in areas not tied to any specific degree program. They are designed to meet institutional requirements, provide broadening experience or to provide supplemental preparation to support students in their degree.

These are listed below:

6.1 English as a Second Language

These courses are designed to provide English language training for students who do not fully meet the University's English language entrance requirements. Students will be assigned courses based on their level of English or proficiency.

ESL 101 English as a Second Language I (6-0-0)

ESL 101 is a foundational English skills course for reading, listening, speaking and writing.
The course has a strong focus on teaching students the basics of academic writing and grammar structures in preparation for thesis work. Course materials are typically A2 level to help students acquire basic academic English skills required for graduate coursework.

ESL 102 English as a Second Language II (3-0-0)

ESL 102 is a pre- English skills course for reading, listening, speaking and writing. The course continues to focus on building academic writing and grammar skills and also have more emphasis on reading for academic purposes. Course materials are typically B1 level to help students further develop pre-intermediate English skills required for graduate coursework.

ESL 103 English as a Second Language III (3-0-0)

ESL 103 is an upper-intermediate English skills course for reading, listening, speaking and writing. The course helps to further develop academic English skills necessary to successfully complete research and thesis work. Course materials are typically B2 level to help students refine upper-intermediate English skills required for graduate coursework.

6.2 Enrichment Program – WEP Courses

The Winter Enrichment Program (WEP) takes place in January each year and is designed to broaden students' horizon.WEP is an essential and core requirement of the degree programs at KAUST. Satisfactory completion of at least one WEP is required of all M.S. students as part of the completion of the degree requirements. Ph.D. students who did not receive their M.S. Degree at KAUST are also required to satisfactorily complete at least one WEP. To satisfy this mandatory requirement, full participation must occur within a single WEP period.

6.3 Innovation and Economic Development

Innovation and Economic Development (IED) courses are meant as a broadening experience and are not technical electives. Students should consult with their program to ensure credits can be applied toward their degree.

6.3.1 IED 210 – Technology Innovation and Entrepreneurship (3-0-3)

This course introduces students to using an entrepreneurial and design thinking view to solving real-world challenges including the pathway to commercializing research. It is about changing methods of thinking and equipping graduate students to be able to understand and manage innovation in the corporate world. This course is open to all M.S. students as an elective and to Ph.D. students with permission of their academic advisors.

6.3.2 IED 220 – New Venture and Product Innovation Challenge (6-0-6)

This intensive 8 week module will give a small select group of students, the opportunity and time to develop a detailed value proposition for a product based on an existing piece of intellectual property. This technology may be from the KAUST IP portfolio or potentially from a corporate partner. As part of the program, students will be provided with an overview of key creative subjects related to new product development including; key aspects of intra/entrepreneurship, innovation management including new product development, Go-to-Market strategies as part of commercialization roadmaps, as well as general knowledge on relevant creativity and design thinking. It will also enable students to develop these skills in a full time, heavily mentor-led and experiential learning environment that includes regular pitches and feedback from a wide range of pre-selected mentors from both inside and outside KAUST including international experts.

7. Grading

The KAUST grading system is a 4.0 scale utilizing letter grades and these are the only grades that will be assigned:

A	=	4.00	C	=	2.00
A-	=	3.67	C-	=	1.67
B+	=	3.33	D+	=	1.33
B	=	3.00	D	=	1.00
B-	=	2.67	D-	=	0.67
C+	=	2.33	F	=	0.00
I	=	Incomplete			
IP	=	In-Progress			
W	=	Withdrew			
S	=	Satisfactory			
U	=	Unsatisfactory			
WF	=	Withdrew-Failed			

7.1 Incomplete Grades

Students who complete the majority of the requirements for a course but are unable to finish the course may receive an Incomplete (I) grade. A grade of Incomplete will be assigned only with the consent of the instructor of the course after the instructor and the student have agreed on the academic work that needs to be completed and the date it is due (but no later than the end of the second week of the following semester or session). When the requirements for the course are completed, the instructor will submit a grade that will replace the Incomplete grade on the student's academic record. 'Incompletes' not completed by the end of the second week of the following semester or session will be changed to Failing (F) grades.

Grades for students that are due to Graduate
Note that any Incomplete grades (as well as Fail grades) will mean a student will not graduate or receive a diploma during the Commencement Ceremony.

Incomplete grades are granted to individual students on a case-by-case basis. Incomplete grades should not be used as a mechanism to extend the course past the end of the Semester. Students are allowed only one Incomplete grade while in a degree program at KAUST.

7.2 In-Progress Grades

Thesis Research (297) or Dissertation Research (397) should be graded as In-Progress (IP) or Unsatisfactory (U) for each semester. These 'IP' Grades will be converted by the Registrar's Office to 'S' Grades for all semesters once the office has been notified that the thesis or dissertation has been submitted to the library.

7.3 Research and Seminar Courses

297 =	Thesis Research	-Either 'IP' or 'U'
397 =	Dissertation Research	-Either 'IP' or 'U'
295/395 =	Summer Internship	-Either 'S' or 'U'
298/398 =	Seminar	-Either 'S' or 'U'
299/399 =	Directed Research	-Either 'S' or 'U'

8. Academic Standing

A student's academic standing is based on his/her cumulative performance assessment and a semester performance based on the number of credits earned and GPA during the most recently completed semester.

Academic Standing classifications are divided into four categories of decreasing levels of Academic Performance:

- Good Standing
- Academic Notice
- Academic Probation
- Academic Dismissal

Cumulative Grade Point Average

- A minimum GPA of 3.0 must be achieved in all coursework.
- Individual courses require a minimum of a B- for Course credit.

Cumulative Assessment

GPA	Academic Standing
3.00-4.00	Good Standing
2.67-2.99	Academic Notice
2.33-2.66	Academic Probation
Below 2.33	Academic Dismissal

S/U Performance	Academic Standing
0-2 Credits	GPA Standing
3-5 Credits	GPA Standing less one category

6-8 Credits	GPA Standing less two categories
9+ Credits	Academic Dismissal

Semester Assessment (Registered in 12 Credits)

Credits Earned	Academic Standing
12+ Credits	GPA Standing
9-11 Credits	GPA Standing less one category
6-8 Credits	GPA Standing less two categories
0-5 Credits	Academic Dismissal

Semester Assessment (Registered in 9 Credits)

Credits Earned	Academic Standing
9+ Credits	GPA Standing
6-8 Credits	GPA Standing less one category
3-5 Credits	GPA Standing less two categories
0-2 Credits	Academic Dismissal

Summer Session Assessment

Credits Earned	Academic Standing
6 Credits	GPA Standing
3-5 Credits	GPA Standing less one category
0-2 Credits	GPA Standing less two categories

Definitions:

Good Standing

Student is making satisfactory academic progress towards the degree.

Academic Notice

Student is not making satisfactory progress towards the degree. A student placed on Academic Notice will be monitored in subsequent semesters to ensure satisfactory progress towards the degree (see Good Standing). If the student's performance does not improve in the following semester, the student will be placed on Academic Probation.

Academic Probation

Student is not making satisfactory progress towards the degree. A student placed on Academic Probation will be monitored in subsequent semesters to ensure satisfactory progress towards the degree (see Good Standing). If the student's performance does not improve in the following semester, the student will be academically dismissed.

Academic Dismissal

Student is not making satisfactory progress towards the degree and is unlikely to meet degree requirements. Dismissed students will be required to leave the University. If deemed eligible, dismissed students will have one week from receiving Notice of Dismissal to file an Appeal.

Appeal Process for Students Academically Dismissed

If the student is eligible to appeal, he/she must submit a written explanation why the dismissal should be rescinded along with any supporting documentation. The Committee on Academic Performance will hear the appeal and make a decision to grant or deny the appeal based on the appeal and documentation, the student's past performance and the likelihood that the student is capable of successfully completing his/her academic program. If the appeal is denied, the student will be required to leave the University. The decision of the committee is final – no additional appeals are permitted.

S/U Protection

Due to the significant impact of Unsatisfactory (U) Grades, a Faculty Member giving a 'U' Grade for a course involving six or more credits must obtain concurrency of the Dean prior to submitting the grade. If the grade is given for only a single class (including Research Credit), the number of credits will be capped at six when using the Academic Standing Table displayed above.

Returning to Good Standing

A student not in Good Standing due to a GPA deficiency may return to Good Standing by improving his/her cumulative GPA such that it meets or exceeds 3.0. A student not in Good Standing due to 'U' Grades may return to Good Standing by completing at least twelve credits during the subsequent semester with no 'U' grades and a semester GPA of at least 3.0 in traditionally graded courses.

9. Transferring Credits

A student may petition to transfer graduate credits from KAUST or another University upon approval of the Program Director and the Registrar.

Each student's application will be reviewed on a case-by-case basis.

The following rules apply:

- Students entering the program with an M.S. Degree from KAUST may transfer unused coursework toward the Ph.D. program requirements subject to program level approval.
- Up to three graduate-level courses not to exceed nine credits may be transferred for credit. Courses already used for another degree cannot be used as transferred credits.
- The course grade for any course to be transferred must be a 'B' or above.
- Courses transferred for degree credit must have been taken within three years prior to admission to KAUST.
- The student must submit a completed KAUST Transfer of Credit Form and include the Course Syllabus and Course Description.
- The student is responsible for supplying an official transcript:
- The transcript may be no more than three months old.
- The transcript must be in English or accompanied by a certified English translation.
- The Grading Key must be included with the transcript.
- The Transcript must include the course name, level, grade and credit value.
- The credit value of the course must be equivalent to a minimum of three KAUST credit hours.

Course Transfer and Equivalency

Graduate credit hours taken from any KAUST program may be applied to other KAUST graduate programs under the guidelines of the degree program to which the student is admitted. Graduate courses taken from another University or KAUST program that are equivalent in level and content to the designated courses in a major track may be counted towards meeting the major track requirement if their equivalence is confirmed by the Program Director.

Students transferring from other Ph.D. programs may receive some Dissertation Research and Coursework credit units on a case-by-case basis for related work performed at their original Institution. However, such students must satisfy the written and oral requirements for a research proposal (if the proposal had been submitted and approved at the original Institution, the proposal may be the same, if approved by the research advisor). The minimum residency requirement for enrolment of such students at KAUST is two years.

10. Policy for Adding and Dropping Courses

A course may be added during the first week of the semester. Students may add courses after the first week with the permission of the instructor. Instructors have the right to refuse admission to a student if the instructor feels that the student will not have the time to sufficiently master the material due to adding the course late. A course may be dropped without penalty at any time during the first two weeks of the semester. Between the second and ninth week, students can drop a course but the course will appear on the student's transcript with the grade of Withdraw (W). After the ninth week of a full semester, courses may be dropped only under exceptional circumstances and with the approval of the Course Instructor, the Program Director and the Registrar.

11. Program Planning

It is the sole responsibility of the student to plan her/his graduate program in consultation with her/his advisor. Students are required to meet all deadlines. Students should be aware that most core courses are offered only once per year.